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Trials of the Sinkkilä HMF Scarifier in North Central British Columbia

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Trials of the Sinkkilä HMF Scarifier in North Central British Columbia

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ABSTRACT

The Sinkkilä HMF Scarifier, manufactured in Finland, was field-tested in British Columbia and Alberta in 1986. The scarifier was imported by Canadian Forestry Equipment Ltd., and leased by Forest Lease Inc. to a Prince George contractor.

The Sinkkilä HMF can provide intermittent scalps, continuous shallow furrows, or mounds, depending upon the angle of the ripper and the hydraulic braking applied to it. The prime mover used by the operator was a 113 kW (152 hp) John Deere 740 skidder. The Sinkkilä contains its own hydraulic system in each ripper arm for the braking function and only uses the skidder's hydraulics for raising the unit for transport or manoeuvering.

The Forest Engineering Research Institute of Canada (FERIC) monitored two sites where mounding treatments were the objective. Block 1 near Hudson Hope was a cleared and windrowed aspen site. The soils were fine-textured, stone-free, and moist. Slash levels were low, at 40.5 m^3/ha. The Sinkkilä was successful in producing acceptable mounds on 76% of the attempts, with 1152 attempts per hectare, at a productivity of 1.94 ha/PMH (Productive Machine Hour).

Block 2, northwest of Vanderhoof, was treated during a period when overheating problems were being experienced with the Sinkkilä's hydraulic system. The overheating problem affected the braking of one of the rippers. The site had been logged, and slash levels averaged 165 m^3/ha. The soil was sandy loam, with frequent stones. Only 34% of the mound attempts were successful on this site. The low success rate was due to machine malfunction, stony soils, and high slash levels. Alternative planting microsites were tallied at each attempt location. Ninety-one percent had an alternative available, with most occurring in combination mineral soil and organic material. Productivity on this site was 1.52 ha/PMH, with 1195 attempts per hectare. The prescription of raised planting sites could not be met on this site and the machine was retired for repair and modification.

Overall availability of the Sinkkilä HMF Scarifier was poor. The leasor and contractor will work with the machine in the winter of 1987 to solve the overheating problems in the hydraulic braking system. If successful, further testing will be done in 1987 to determine where the Sinkkilä can be used successfully.

PREFACE

This study was funded by the Forest Resource Development Agreement (FRDA) under research project 1.10 and the Forest Engineering Research Institute of Canada (FERIC). During the initial field work, B.J. Sutherland of the Canadian Forestry Service (CFS), Great Lakes Forestry Centre (GLFC),assisted FERIC and B.C. Ministry of Forests and Lands (MOFL) personnel by instructing in the CFS Standard Assessment Procedure for Silviculture Equipment. The method of assessing mounds used in this study was determined on-site with discussion and agreement between CFS, MOFL, and FERIC personnel.

The author is grateful for the assistance provided by B.J. Sutherland (GLFC), R.G. McMinn and M. Grismer (CFS, Pacific Forestry Centre), and L.R. Bedford (FRDA 1.10 Project Leader, MOFL, Victoria); for the cooperation of the contractor and operator, F. Diedrichsen and R. Adams, Arboress Enterprises Ltd., Prince George, and R. Burkeholder, Westar Timber Ltd., Vanderhoof; and for assistance in field work, data analysis, and report preparation by FERIC personnel A.L. Sinclair, A. Alger, J. Breadon, K. Francoeur, and D. Miller.

TABLE OF CONTENTS

ABSTRACT		iii
PREFACE		iii
1	INTRODUCTION	1
2	PRIME MOVER AND SCARIFIER	1
3	STUDY METHOD	5
4	DESCRIPTION OF SITES AND PRETREATMENT ASSESSMENT	5
5	TREATMENT AND PRODUCTIVITY	8
6	POST-TREATMENT ASSESSMENT	9
7	DISCUSSION	16
8	SUMMARY AND CONCLUSIONS	16
9	LITERATURE CITED	18

APPENDICES

1	Prime mover and scarifier	19
2	Sinkkilä HMF Scarifier control box and options mode	20
3	Classification of mound attempts	21

TABLES

1	Slash assessment	7
2	Stump assessment	7
3	Soil, ground-moisture, and ground-roughness assessments	7
4	Summary of time and productivity assessment	8
5	Distribution of mound classes	10
6	Mound dimensions	11
7	Scalp dimensions	13
8	Alternative microsites for planting	13
9	Reasons for poor mound formation	13
10	Spacing of mound attempts	15

FIGURES

1	The John Deere 740A line skidder and Sinkkilä HMF Scarifier	2
2	Modifications to the Sinkkilä HMF Scarifier	3
3	Sinkkilä HMF Scarifier operating on Block 1, Hudson Hope	4
4	Block 1, Hudson Hope	5
5	Block 2,Vanderhoof	6
6	Sinkkilä HMF Scarifier at Block 2, Vanderhoof	9
7	Examples of mound attempts on Block 1, Hudson Hope	12
8	Examples of mound attempts on Block 2, Vanderhoof	17

1 INTRODUCTION

The use of Scandinavian scarifiers in Canadian boreal forests has become common with the introduction and acceptance of Swedish and Finnish spot scarifiers and disc trenchers. As operational experience with this equipment increases, suitable sites and limitations are identified. At the same time, prescriptions for site preparation in boreal forests are becoming more specific and sophisticated. Experimental success with mounding treatments (overturned organic material covered with mineral soil) has generated interest in equipment with potential for producing inverted humus mounds.

The Sinkkilä, developed as a patch scarifier, has been used in Finland during the past 20 years. In response to the interest in inverted humus mounds, the Sinkkilä was further developed as a combination patch-mounding machine. Teraskomponentti Ky, the manufacturer in Finland, produced a machine with modifications to improve its mound-forming capability, called the HMF Scarifier. Canadian Forestry Equipment Ltd. and Forest Lease Inc. of Edmonton found sufficient support in British Columbia and Alberta for a testing program, and imported a unit in the spring of 1986. (See Appendix 1 for the addresses of the manufacturer and distributor.)

This report details two areas treated by this scarifier/mounder during the 1986 field season. It outlines the difficulties encountered in the trial period, and describes the results of the treatment and the potential for modification and use in the future.

2 PRIME MOVER AND SCARIFIER

The prime mover chosen by the leasor and contractor for the scarifier was a John Deere 740A line skidder. The listed net power rating for this model is 113 kW (152 hp). This unit had approximately 8400 hours at the time of study in July 1986. The machine was a 1976 model and had been extensively rebuilt during the past 2 years. It was equipped with a winch and tilting blade. Details on the prime mover are in Appendix 1.

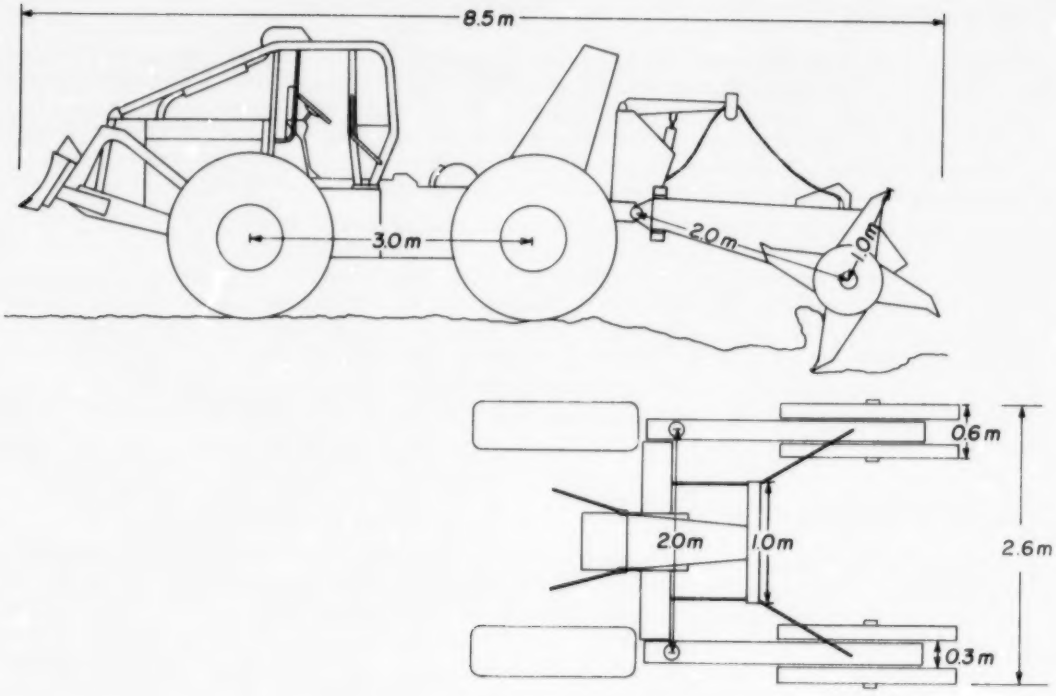
The 1986 model of the Sinkkilä HMF was a modification of the earlier patch scarifier units, with reshaped rippers and modified electrical controls to improve mounding capability. The line drawings in Figure 1 illustrate the prime mover and Sinkkilä, and show key dimensions. Modifications made by the contractor will be noted later.

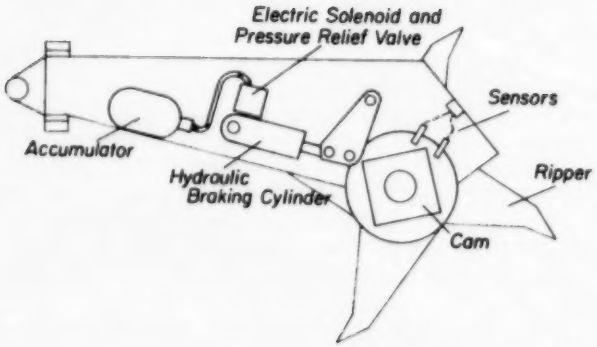
The Sinkkilä consists of two scarifier units, each with four pairs of rippers. The action of the rippers is controlled from the cab of the skidder. The hydraulic assembly and position sensors (shown in Figure 1) carry out the functions set by the operator. For ease in manoeuvering and transport of the Sinkkilä, the ripper arms can be raised. The crossbar is raised using the skidder's hydraulic system. The ripper arms, in turn, are raised by the chain and pulley system, and swing inward towards each other.

The mode of operation depends upon two factors: the angle of the ripper and the hydraulic braking applied to it. The HMF unit is capable of providing intermittent scalps, continuous shallow furrows, or mounds. The site preparation sequence consists of two steps. A brake is applied to the ripper wheel in Step I and the ripper is drawn through the organic layer and into the soil. In Step II, the brake is released and the ripper rotates. When mounding, the angle of the ripper is shallow and the ripper is drawn more deeply into the soil. The organic and mineral soil accumulation overturns in Step II and a mound is formed. When scalping is required, the ripper angle in Step I is more vertical and a shallower scalp results. The settings for each control depend upon the site and the type of spot required. Generally, several passes on the site can determine which settings are most appropriate. A pressure relief valve allows the ripper to release when it catches on a solid object, such as a stump or stone. More detail on the control options is in Appendix 2.

Mounting the Sinkkilä was straightforward, and did not require hardware modifications to the prime mover. The Sinkkilä does not require hydraulic capacity from the prime mover except for lifting the unit, but the scarifier requires 24 volts for operation. Because the John Deere 740A operates with a 12-volt system, a 12-volt/24-volt alternator and a second 12-volt battery were added. The batteries, when connected serially, were adequate to meet the Sinkkilä's electrical requirements.

There were initial start-up problems in determining the hydraulic oil pressure for the ripper-arm cylinders. This was resolved through trial-and-error and consultation with other users of this model in Europe.

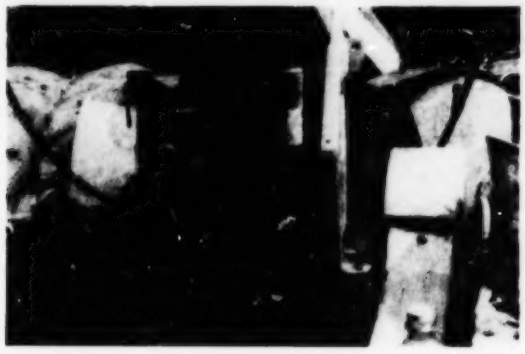




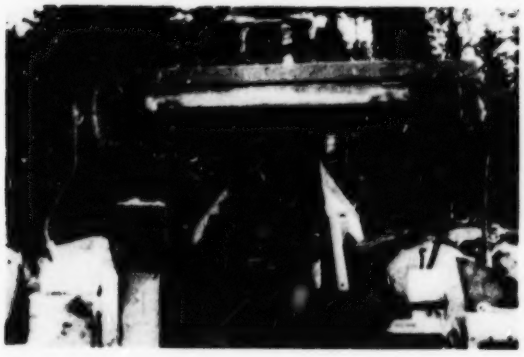
Gross Weight of
Sinkkilä HMF Scarifier
3200 kg

FIGURE 1. The John Deere 740A line skidder and Sinkkilä HMF Scarifier.

After a period of field treatment, the contractor found several modifications were necessary to reduce operational problems. The ripper arms are mounted so that they can pivot and swing. On side slopes, these arms knocked against and crossed over each other. On one occasion, this crossing resulted in a broken lift cylinder. The contractor added stoppers to the cross-frame to restrict the inward movement of the arms. The lifting cross-bar was then widened from 1 to 1.6 m to accommodate the wider raised position of the arms. The chains for raising the arms were replaced by wire rope. These modifications are shown in Figure 2.



Bracing to prevent ripper-arm swing→



←Reinforced and extended cross-bar mounted over original

FIGURE 2. Modifications to the Sinkkilä HMF Scarifier.

Dual tires were used at the Hudson Hope site to improve flotation (Figure 3). The overall width of the pair was 130 cm. Later, the skidder was equipped with Goodyear Terra Tires, with 112 cm widths. These were used at Vanderhoof.

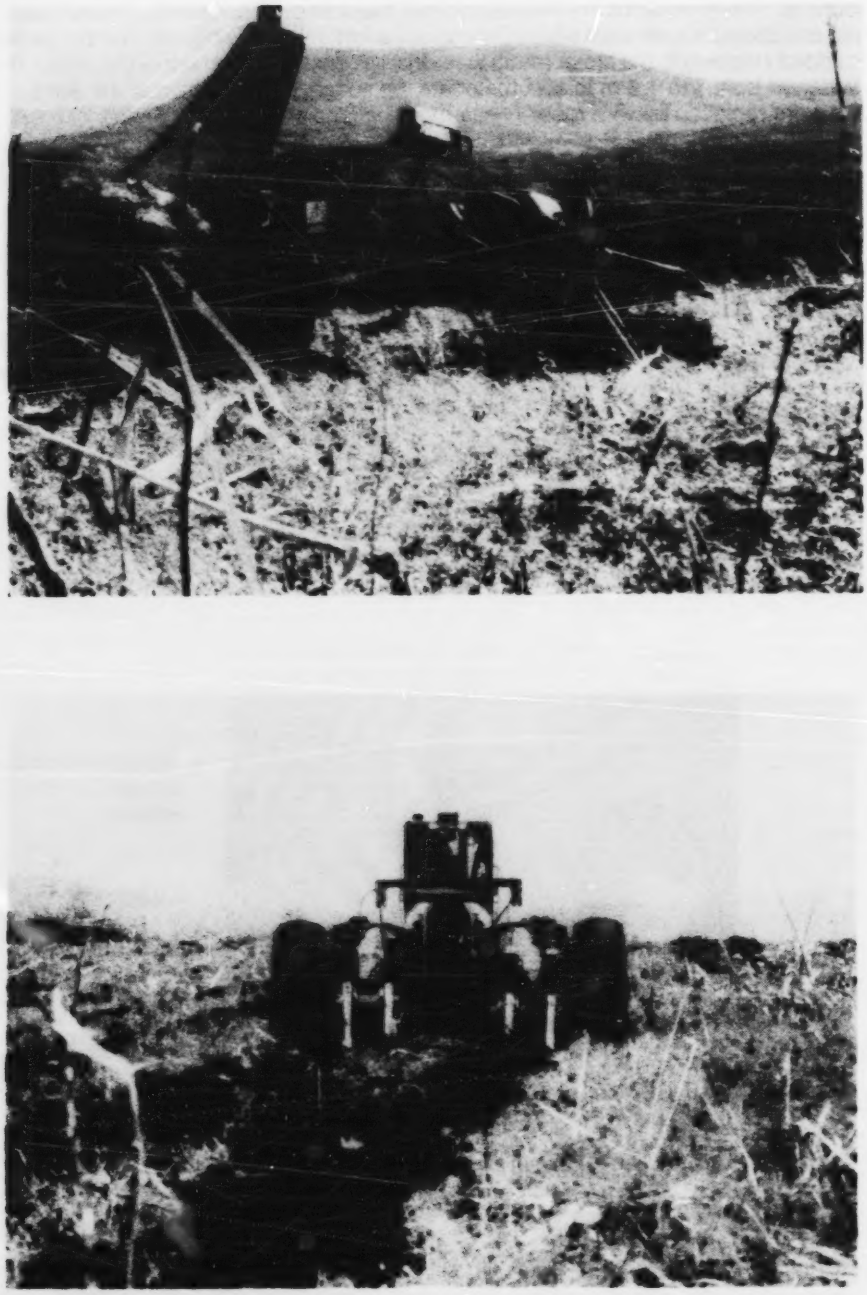


FIGURE 3. Sinkkilä HMF Scarifier operating on Block 1, Hudson Hope. Note the dual tires used on this site.

3 STUDY METHOD

The procedure used in assessing the sites and treatment by the Sinkkilä followed the Canadian Forestry Service (CFS) Standard Assessment Procedure (Sutherland 1986). Pretreatment assessment included transect sampling to estimate slash volume by the line-intersect method, slash height, soil condition, vegetation cover, ground roughness, and stump density. At the second block, stumps and ground roughness obstacles were relatively rare, but were felt to be significant. Consequently, an additional procedure — systematically located 0.01-ha circular plots — was added to assess these two parameters more effectively. Treatment time-monitoring and productivity calculations followed FERIC and CFS methodology.

Post-treatment assessments were based on a series of transects, each consisting of 20 mound attempts. The categories for mound classification were determined on-site at Hudson Hope by CFS, B.C. Ministry of Forests and Lands (MOFL), and Forest Engineering Research Institute of Canada (FERIC) personnel before the study. A brief description of the post-treatment mound assessment classification is included in Appendix 3.

More details on study method can be found in Sutherland (1986), Ryans (1982), or from the author.

4 DESCRIPTION OF SITES AND PRETREATMENT ASSESSMENT

During the 1986 trial period, two sites were monitored by FERIC. In July, Block 1 at Johnson Lake near Hudson Hope was studied and in October, Block 2 at Barlow Lake near Vanderhoof was monitored.

Block 1 was a Boreal White and Black Spruce (BWBS) site in the Dawson Creek Forest District. The site was treated as an aspen rehabilitation project, funded by the Forest Resource Development Agreement (FRDA). During the winter 1985-86, the aspen was removed with a brush blade and crawler tractor, and piled in windrows (Figure 4). Mounding treatment with the Sinkkilä was done during July and August 1986. Windrow burning was scheduled for fall, and planting scheduled for spring 1987. The site-preparation objective was 1400 mounds per hectare of acceptable configuration.

FIGURE 4. Block 1, Hudson Hope. Note the windrow of aspen material in the background.

Block 2 was located on the Barlow Lake Road northwest of Vanderhoof and was within the Moist Interior Plateau Sub-Boreal Spruce (SBSe) subzone. The area was logged by Westar Timber Ltd. in summer 1984 (Figure 5). There was no other treatment of the site before the use of the Sinkkilä. The objective here was 1440 mounds per hectare of acceptable configuration.

FIGURE 5. Block 2, Vanderhoof. A scarified patch is at the lower right of the photo.

The results of the pretreatment surveys are shown in Tables 1, 2, and 3. The two sites were different, both in slash and soil conditions. There was a similar amount of small slash material (of 1- to 5-cm diameter) on the two sites, but Block 2 had more than twice as many large slash pieces (greater than a 5-cm diameter). These two factors, plus the previous treatment (shearing and piling on Block 1 compared to logging only on Block 2) contributed to a much lower slash depth on Block 1 (4.3 cm compared to 15.0 cm). Total slash volume was 49.0 m^3/ha on Block 1 compared to 165.1 m^3/ha on Block 2. Both sites had similar numbers of stumps but they were larger and taller on Block 2.

TABLE 1. Slash assessment

Location	Pieces per 20 m of lineal tally		Diameter		Avg length (m)	Depth		Volume					Type of slash
	1-5 cm (no.)	>5 cm (no.)	Avg >5 cm (cm)	Range >5 cm (cm)		Avg (cm)	Range (cm)	Avg 1-5 cm (m^3/ha)	Range 1-5cm (m^3/ha)	Avg >5 cm (m^3/ha)	Range >5 cm (m^3/ha)	Total (m^3/ha)	
Block 1 Hudson Hope	38.4	4.8	10.6	6-32	1.4	4.3	0-35	8.5	2.4-19.0	40.5	3.9-133.5	49.0	Deciduous
Block 2 Vanderhoof	36.0	11.7	13.2	6-32	3.7	15.0	0-75	8.0	2.5-17.9	157.1	39.2-398.3	165.1	Coniferous

TABLE 2. Stump assessment

Location	Frequency (no./ha)	Height		Diameter		Species				
		Avg (cm)	Range (cm)	Avg (cm)	Range (cm)	Trembling aspen (%)	Black cottonwood (%)	White birch (%)	Lodgepole pine (%)	Subalpine fir (%)
Block 1 Hudson Hope	413	14.3	6-48	19.8	6-50	80	18	2		
Block 2 Vanderhoof	387	31.6	15-60	35.0	15-56				53	47

TABLE 3. Soil, ground-moisture, and ground-roughness assessments

Location	Soil depth			Avg depth mineral soil (cm)	Avg depth LFH (cm)	Stoniness (%)	Soil texture	Ground moisture	Ground condition[a]	Ground roughness[b]
	<12.5 cm (%)	12.5-27.5 cm (%)	27.5 + cm (%)							
Block 1 Hudson Hope	3	4	93	33	9.4	19	Silty loam	Moderately moist (moist, wet)	4(3)	1(2) very even
Block 2 Vanderhoof	10	45	45	25	6.3	92	Sandy loam	Moist (very moist, moderately moist)	3(2)	3(2,4) uneven

Classes in brackets make up greater than 10% of the sample, and are listed in order of magnitude.

[a] Ground condition is a composite of soil texture and soil moisture. Classes range from 1 to 5, with 5 being wet, fine-textured soils.

[b] Mellgren (1980)

The soils on the two sites differed. Block 1 had the fine-textured soil typical of sites northeast of the Rockies. There were few stones, a consistent soil depth greater than 30 cm, and an average organic depth (LFH) of 9.4 cm. The absence of surface obstacles resulted in an even ground roughness class. The fine-textured moist soils on this site gave a ground condition of 4. Soil pits showed a hardpan layer at a 40-cm depth. Drainage was therefore poor on moisture-receiving microsites. Block 2 had coarser-textured soils, an average mineral soil depth of 25 cm with 92% stoniness, and an average LFH depth of 6.3 cm. Ground condition was better for equipment travel than Site 1, with a rating of 3. However, the presence of windfall, holes, and large slash combined for an uneven ground roughness, class 3. Soil pits, 40 cm deep, showed many stones 5-20 cm in size throughout.

Vegetative cover was not heavy on either site. Average cover on Block 1 was 17%, comprised primarily of spirea (25%), rose (17%), and grasses (15%). Some willow and ash were present as brush but were in low numbers. On Block 2, vegetative cover averaged 19%; primary species were grasses (25%), raspberry (24%), fireweed (21%), and low alder shrubs (16%). Alder brush (taller than 1.5 m) was present occasionally as well.

Both blocks were flat, with a slope average of 5%. Each had short sections of 10% at one end. The average length in the direction of travel was 350 m in Block 1 and 250 m in Block 2.

5 TREATMENT AND PRODUCTIVITY

During the treatment of Block 1, the Sinkkilä was operating with electrical and hydraulic systems functioning reasonably well. (Occasional malfunctioning of one ripper brake occurred.) As the summer and fall progressed, the machine began to experience severe overheating problems and malfunctions in the braking of the rippers. These difficulties show partly in the time analysis (Table 4) and more clearly in the post-treatment assessment results (Tables 5-9).

TABLE 4. Summary of time and productivity assessment

Activity	Block 1 Hudson Hope			Block 2 Vanderhoof		
	Time (min)	% of total	Avg/occurrence (min)	Time (min)	% of total	Avg/occurrence (min)
Productive time[a]						
Scarify	161.1	85		157.7	70	
Turn, position	12.8	7	0.49	9.8	4	0.35
Delay - prime mover-wet ground	10.8	6	0.45	-		
Delay - slash	0.1			2.9	1	0.49
Delay - Sinkkilä-mechanical	0.7			35.1	16	7.0
Delay - reconnaissance	-			0.6		
Delay - talk to FERIC, supervisor	1.6	1		7.9	4	
Travel within block	1.6	1		0.8		
Travel to truck	-			10.5	5	
Total productive time	188.7			225.3		
Productive machine hours (PMH)[a]	3.15hours			3.76 hours		
Area treated	6.1 ha			5.7 ha		
Productivity	1.94 ha/PMH			1.52 ha/PMH		
Avg travel speed - Scarify time only	4.2 km/h			4.1 km/h		

[a] Includes individual delays of less than 15 minutes.

Productivity on a per-hectare basis was greater on Block 1 — 1.94 ha/PMH (Productive Machine Hour) — compared to 1.52 ha/PMH on Block 2. A larger portion of the machine time on Block 1 was spent site preparing and turning, 92% compared to 74% on the second block. Short delays due to mechanical problems were a larger component on Block 2 where 16% of the PMH was spent attempting to solve overheating problems. In fact, after the machine completed the area presampled by FERIC, it was returned to Prince George for repair.

The largest delay component on Block 1 related to the wet conditions and bearing capacity of the soil. Soil moisture accumulated in depressions, providing poor traction for the prime mover. The clean site was an advantage for the functioning of the Sinkkilä, but the herbaceous and grassroot mat did not provide good tractive conditions for the prime mover. At one point the prime mover became stuck and was not freed until the next day.

Treatment at Block 2 (Figure 6) was affected to some degree by the slash and residual saplings. The operator used his blade to push aside slash material and delays did not result from stumps or slash. These site conditions, however, were apparent in the post-treatment analysis as causes of poor mound formation.

FIGURE 6. Sinkkilä HMF Scarifier at Block 2, Vanderhoof. Note the wide tires on the skidder.

Average travel speed for both sites was similar, 4.2 km/h at Block 1 and 4.1 km/h at Block 2. Productivity differences, therefore, were due to distribution of time and differences in width between passes.

6 POST-TREATMENT ASSESSMENT

The distribution of mound classes at the two areas is shown in Table 5. Although four classes were considered to be acceptable, the preferred mineral capping depth was 6 cm or greater over an inverted organic layer. The Sinkkilä treated Block 1 more successfully than Block 2; 81% of the attempts resulted in acceptable mounds compared to 52%. When mounds with poor ground contact were judged unacceptable, the Hudson Hope site had twice as many successful attempts, compared to Vanderhoof. The mound dimensions summarized in Table 6 show higher mounds at the Hudson Hope site, with an overall difference of 10 cm between the two blocks. The Vanderhoof mounds were also generally smaller in both length and width. Figure 7 illustrates examples of mound attempts at Hudson Hope.

TABLE 5. Distribution of mound classes

Mound class	Block 1 Hudson Hope			Block 2 Vanderhoof		
	Good ground contact (%)	Poor ground contact (%)	Total (%)	Good ground contact (%)	Poor ground contact (%)	Total (%)
Acceptable mound classes						
Greater than or equal to 14 cm mineral soil in cap over inverted organic layer	32	2	34	3	<1	3
6-13 cm mineral soil in cap over inverted organic layer	35	2	37	23	10	33
3-5 cm mineral soil in cap over inverted organic layer	8	1	10	8	8	16
Greater than or equal to 5 cm well-decomposed inverted organic layer over undisturbed organic	1	0	1	0	<1	<1
Subtotal	76	5	81	34	18	52
Unacceptable mound classes						
Less than or equal to 2 cm mineral soil in cap over inverted organic layer			1			3
Mineral cap over mineral soil			<1			0
Mineral cap over undisturbed organic			1			0
Inverted organic mound			2			12
Organic mound, not inverted			6			7
Organic over mineral, not inverted			<1			0
Vertical mound, not overturned			1			3
No mound			7			23
Subtotal			19			48
Total			100			100

TABLE 6. Mound dimensions

Mound class	Block 1 Hudson Hope			Block 2 Vanderhoof		
	Avg height (cm)	Avg length (cm)	Avg width (cm)	Avg height (cm)	Avg length (cm)	Avg width (cm)
Greater than or equal to 14 cm mineral soil in cap over inverted organic layer	38	45	55	34 (33)[a]	63 (64)	55 (58)
6-13 cm mineral soil in cap over inverted organic layer	36	46	48	29 (26)	42 (42)	43 (43)
3-5 cm mineral soil in cap over inverted organic layer	37	36	43	24 (19)	35 (32)	35 (37)
Greater than or equal to 5 cm well-decomposed inverted organic layer over undisturbed organic				13	27	40
Overall	37	44	50	27 (25)	40 (41)	41 (43)

[a] Dimensions in brackets are averages for mounds with good ground contact.

The Sinkkilä was successful on both blocks in terms of preparing scalps (Table 7), with over 90% of the attempts resulting in removal of organic material and exposure of mineral soil. At Hudson Hope, the scalps were deeper, with steep sides. The ripper angle for mound formation gives a quick and deep entry into the soil. Planting would not take place at the bottom of these scalps on this site because of the moisture conditions. At Vanderhoof, the average scalp depth was 10 cm compared to 20 cm at Hudson Hope. The Sinkkilä's malfunctioning at Vanderhoof affected the braking on the rippers; dragging of the rippers at the steeper scalping angle was more common than digging into the soil. The description of the alternative microsites shown in Table 8 support this difference in ripper action. At Hudson Hope, most of the microsites were on the slope adjacent to the mound, and were usually composed of mineral soil loosened by the rippers. At Vanderhoof, both slope and level positions were most common, and many were a combination of mineral and organic soil. Figure 8 shows scalps made by the scarifier on Block 2.

When grass sod was present, mounds were wider than average. Rooting zone was often the shear point.

This mound illustrates deep mineral capping picked up between the two ripper teeth. The notebook is positioned on a ripper indentation.

Several pieces of slash, 5-10 cm in diameter, are under this mound but ground contact is good.

Occasionally mound attempts resulted in an incomplete cycle. This "vertical mound" may have resulted from a release in braking when the ripper caught on the sapling root.

FIGURE 7. Examples of mound attempts on Block 1, Hudson Hope.

TABLE 7. Scalp dimensions

Location	Attempts with scalps (%)	Avg depth (cm)	Avg length (cm)	Avg width (cm)
Block 1				
Hudson Hope	98	20	154	58
Block 2				
Vanderhoof	91	10	122	55

TABLE 8. Alternative microsites for planting

Location	Soil microsite							Microrelief				
	Firm M.S.[a] (%)	Loosened M.S. (%)	O.M.[b] (%)	Ah horizon (%)	Comb. M.S. and O.M. (%)	No alternative available (%)	Total (%)	Slope (%)	Level (%)	Hollow (%)	No alternatives available (%)	Total (%)
Block 1												
Hudson Hope	14	58	1	1	26	0	100	49	32	19	0	100
Block 2												
Vanderhoof	0	23	2	4	62	9	100	37	43	11	9	100

[a] Mineral soil
[b] Organic material

TABLE 9. Reasons for poor mound formation

Reasons	Acceptable mound class poor ground contact			Unacceptable mound class		
	No. occurrences	% of total in category	% of total mounds assessed	No. occurrences	% of total in category	% of total mounds assessed
Block 1 - Hudson Hope						
Slash	7	58	3	8	17	3
Stumps	3	26	1	6	13	3
Root and root mat	1	8	<1	4	9	2
Brush and residuals	1	8	<1	3	6	1
Wet ground	0			2	4	1
Deep organic layers	0			5	11	2
Machine travel pattern	0			3	6	1
Machine error	0			8	17	3
No reason apparent	0			8	17	3
Total Hudson Hope	12	100	5	47	100	19
Block 2 - Vanderhoof						
Slash	7	19	3	42	45	21
Stumps	0			10	10	5
Brush and residuals	23	64	12	14	14	7
Root and root mat	1	3	<1	13	14	7
Decomposing slash	5	14	3	7	7	3
Boulder	0			2	2	1
Machine error	0			8	8	4
Total Vanderhoof	36	100	18	96	100	48

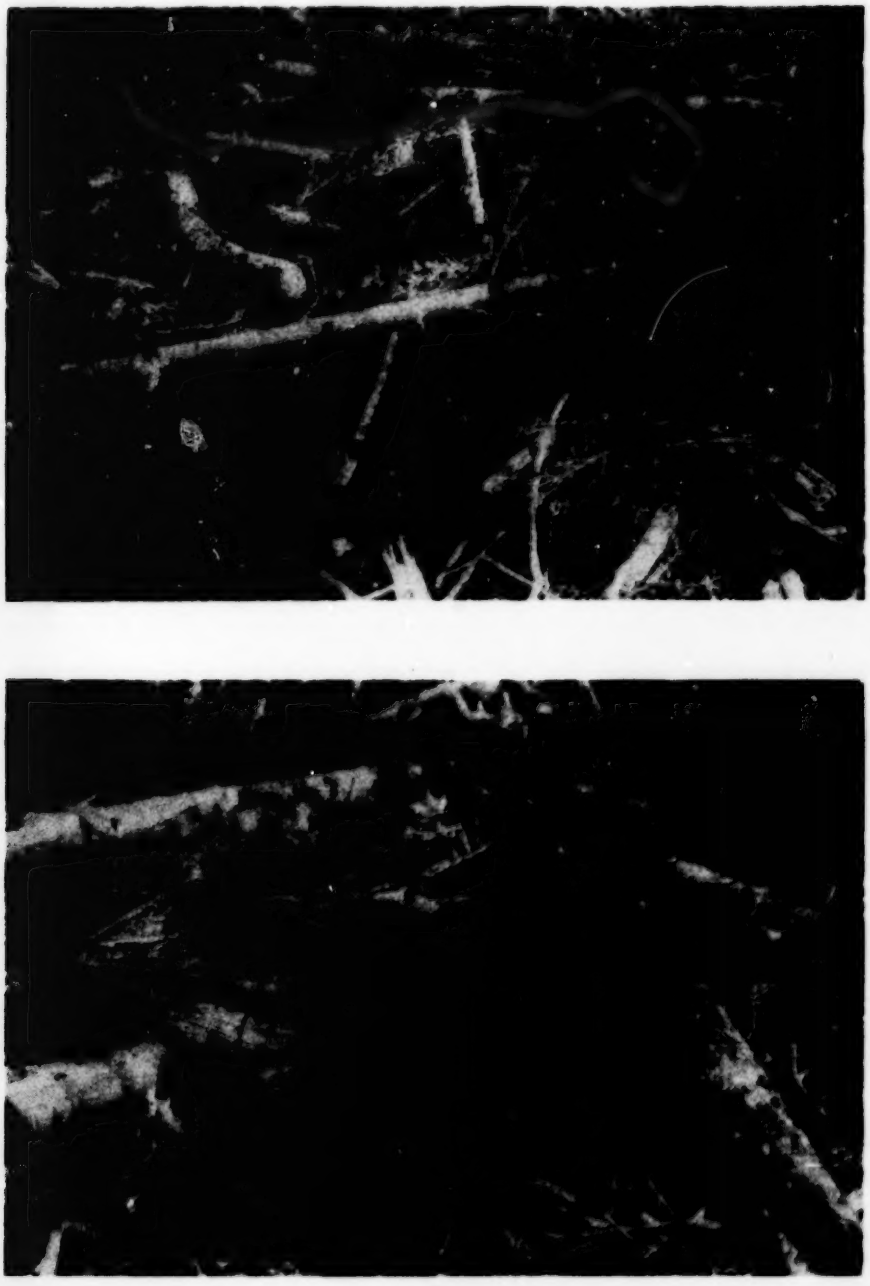


FIGURE 8. Examples of mound attempts on Block 2, Vanderhoof. The scarifier produced scalps as shown in the upper photo. As the rippers brought material forward, it was often distributed over slash (below).

Table 9 summarizes the reasons for poor mound formation on the two blocks. Ground contact at Hudson Hope was good. In the few instances when contact was poor, slash and stumps were the apparent causes. In Block 2, brush and residuals (1.5-3 m in height) accounted for most of the poor ground contact, although both sound and decomposing slash were also important. Unacceptable mound classes at Block 1 were the result of many factors, without any appearing to be significantly more important than others. At Vanderhoof, slash was judged to be the most common cause of poor mounds. However, because the equipment was not functioning well, the more important underlying cause may have been machine malfunction, with the braking system failing to maintain the ripper at the mounding angle. As the ripper entered the ground, it released and "rotated" to the scalping position.

The depth of penetration at Vanderhoof averaged 20 cm, compared to 35 cm at Hudson Hope. Both site characteristics and equipment malfunctions were responsible for the different penetration. Stones were common in the scalps at Vanderhoof and it was likely they would have affected ripper penetration regardless of the function of the ripper brakes.

Table 10 summarizes the distances between mound attempts: along the row, between rippers, and between adjacent passes. Although the distance between mounds within a row was greater at Hudson Hope, in terms of attempts per hectare, this was offset by a greater distance between adjacent passes at Vanderhoof. When these three averages are used to calculate attempts per hectare, the figures are similar: 1152 per hectare at Hudson Hope and 1195 per hectare at Vanderhoof.

TABLE 10. Spacing of mound attempts

	Block 1 Hudson Hope			Block 2 Vanderhoof		
	Avg (m)	S.D.[a] (m)	Range (m)	Avg (m)	S.D. (m)	Range (m)
Distance between mound attempts along row	3.30	0.61	1.1-5.0	2.93	0.81	1.2-5.2
Distance between mound attempts between rippers	2.01	0.22	1.6-2.6	2.08	0.25	1.0-2.5
Distance between mound attempts in adjacent pass	3.25	0.91	1.2-5.7	3.63	0.65	2.1-5.0

[a] Standard Deviation.

7 DISCUSSION

Trial period with the Sinkkilä HMF Scarifier required the usual "debugging" process associated with new imported equipment. The machine's operation during the first 2 months in northern British Columbia was interrupted by modifications to the swing and lift mechanisms. Acceptable mounds were made during this period. The productivity measured by FERIC at the Hudson Hope site, 1.94 ha/PMH, was supported by that monitored on similar sites by the Ministry of Forests and Lands during July. Their figure of 1.72 ha/PMH was measured on 13.5 ha. Success in achieving acceptable mounds was similar to the FERIC study (J. Maxwell, B.C. Ministry of Forests and Lands, pers. comm., Jan. 1987).

Several observations about the mode of operation of the Sinkkilä were noted. The ripper pairs on the Sinkkilä are 30 cm apart, and the mineral soil accumulated by them must have cohesion to be overturned as a unit. Generally, with moist fine-textured soil, a continuous mineral cap was formed, although in some cases material between the rippers was not picked up and the cap was broken. A fine-root structure was advantageous in maintaining a continuous cap. When the machine was moved to northern Alberta, the dry silty soils encountered there were not cohesive, crumbling when the ripper teeth moved through. During a demonstration in mounding mode at the site at Spirit River, north of Grande Prairie, the author noted poor or no mound formation on dry soils. When moist microsites were encountered on the block, a better mound was formed. The hydraulic overheating problems were clearly evident at this time, and faulty ripper braking also contributed to poor success.

In some instances at Hudson Hope, a "jelly roll" formed as the accumulation of organic and mineral soil inverted and turned under. Such a roll makes an undesirable planting spot. This rolling action appeared to be infrequent and may have resulted from a specific combination of root mat, ripper depth and angle, and braking length. A "concertina" effect, the bunching of the organic material, also occurred. When mound height, humus depth, and mineral capping are compared, it is evident that accumulations of organic material did occur. Extended braking length and the ripper's inability to maintain a deep position in the soil were likely the factors here.

8 SUMMARY AND CONCLUSIONS

The Hudson Hope site was flat and free of debris, with fine-textured moist soil. Seventy-six percent of the mound attempts produced acceptable mounds with good ground contact. Of these, 42% had mineral capping of greater than or equal to 14 cm; an additional 46% were 6-13 cm mineral soil capping. The acceptable mounds averaged 37 cm in height, 44 cm in length, and 50 cm in width. Five percent of the attempts were acceptable mound configurations but had poor ground contact, primarily because of slash. Unacceptable mound attempts were caused by slash, machine malfunction, stumps, and deep organic layers. Alternative planting locations were available at all mound-attempt locations, usually in loose mineral soil on a sloped position. Productivity on this block was 1.94 ha/PMH, 1152 attempts per hectare.

Block 2 at Vanderhoof had stony soils and light to medium slash loading (165 m^3/ha). The Sinkkilä overheated in the hydraulic braking system for the ripper teeth and did not perform well mechanically. Only 34% of the mound attempts produced acceptable mounds with good ground contact. Nine percent of these mounds had 14 cm or greater mineral soil capping, and another 68% had 6-13 cm mineral soil capping. Eighteen percent of the attempts had an acceptable soil configuration but did not have good ground contact. Average mound height was 25 cm, and average dimensions were 41 cm in length and 43 cm in width. Poor ground contact was due primarily to brush, residuals, and slash. Slash, roots, brush, and residuals were the obvious reasons for unacceptable mound classes, but mechanical failure of the braking assembly was often the underlying cause. Alternative microsites for planting were available at 91% of the attempt locations. These occurred most commonly on combinations of mineral soil and organic material, on both level and sloped positions. The productivity on this block was 1.52 ha/PMH, with 1195 attempts per hectare.

The trial during 1986 left many questions unanswered. Mechanical unavailability reduced treatment time and therefore the ability to draw conclusions about the potential of the equipment. During June to October, with double-shifting, only 600 ha were treated (F. Diedrichsen, Arboress Enterprises Ltd., pers. comm., Jan. 1987).

The results at Hudson Hope suggest the Sinkkilä could be effective in producing mounds, but these results were not continued through the season. Regardless of the specific mounder used, slash must be removed prior to treatment. Windrowing followed by mounding is one option, but a one machine-pass system would be more cost effective. V-blades on crawlers have been used with other mounders (e.g., B.C. Ministry of Forests and Lands Mounder). The recent development of a skidder-mounted V-blade may be a solution on slash sites and would enable the use of the faster and less expensive skidder as a prime mover. The ability of the Sinkkilä to produce scalps in slash conditions has been shown only to a limited extent. Despite its mechanical problems, it produced scalps at Vanderhoof. However, because the prescription on that site was for raised planting sites, the Sinkkilä's scalps were not the preferred microsite. The flexibility of scalping or mounding with one site preparation implement is attractive.

Because of the difficulties encountered with the machine, a detailed costing of prime mover and scarifier is not appropriate. Purchase costs of the prime mover and scarifier are included in Appendix 1. Target cost of mounding treatment is $200/ha for average conditions, and given the productivity of the equipment, should be achievable provided availability of the Sinkkilä can be improved.

The leasor and contractor will work with the Sinkkilä in the winter of 1987 in an attempt to solve the hydraulic overheating problem. If this can be achieved, the machine can be further tested later in the year and may provide more conclusive results for a variety of sites.

9 LITERATURE CITED

Mellgren, P.G. 1980. Terrain classification for Canadian Forestry. Can. Pulp Pap. Assn., Montreal, Que. 13 p.

Ryans, M. 1982. Evaluation of the Donaren 180D powered disc trencher. Forest Engineering Research Institute of Canada, Point Claire, Que. Tech. Rep. No. TR-54. 38 p.

Sutherland, B.J. 1986. Standard assessment procedures for evaluation of silviculture equipment: a handbook. Can. For. Serv., Great Lakes For. Cent., Sault Ste. Marie, Ont. 96 p.

APPENDIX 1. Prime mover and scarifier

John Deere 740A Line Skidder

Power - @ 2200 engine rpm
Gross 125 kW 167 hp
Net 113 kW 152 hp

Engine - John Deere diesel vertical 6-cylinder maximum torque @ 1200 rpm's 687 Nm (507 lb-ft)

Differentials - front and rear - full differentials with hydraulic lock

Transmission - 8 speeds forward, 4 reverse

Travel Speeds - 2200 rpm, no tire slip
- forward: 2.6-30.0 km/h
- reverse: 3.2-9.3 km/h

Hydraulic System - variable-displacement pump driven from crankshaft
- 2.14 L/s, 13 790 kPa @ 2000 engine rpm

Fuel Tank - 204.4-L capacity

Hydraulic Sump Tank - 68-L capacity

SAE Operating Weight - 13 698 kg

List Price f.o.b. Vancouver - $156 000 January 1987.

Manufacturer and Distributor of Sinkkilä HMF Scarifier

Manufacturer

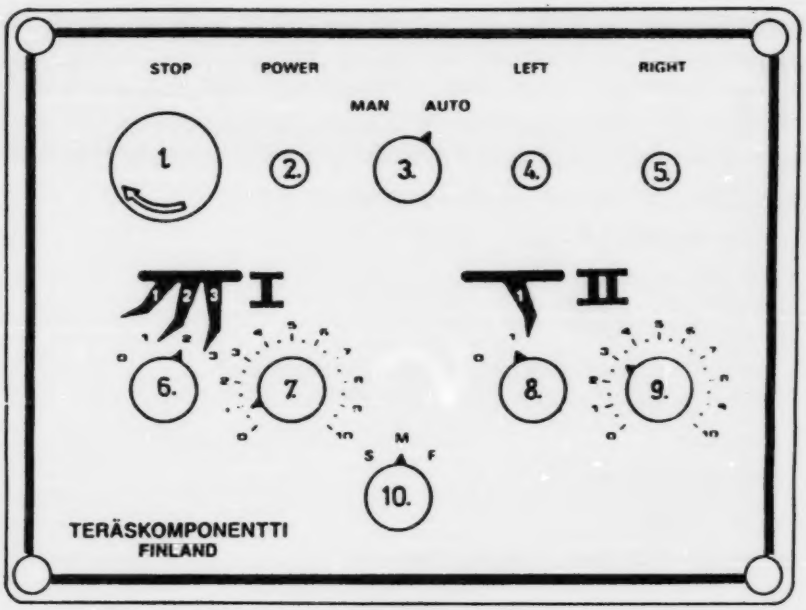
Teraskomponentti Ky
Satalakatu 1
18100 Heinola
Finland

Distributor

Canadian Forestry Equipment Ltd.
17212 - 106 Avenue
Edmonton, Alberta
T5S 1H9
(403) 484-6687

List Price f.o.b. Edmonton - $63 000 January 1987.

APPENDIX 2. Sinkkilä HMF Scarifier control box and options mode



Control Box

1. Main switch for electric current. When switch is depressed, ripper wheels are immediately released for free rolling.
2. Indicator light for main power.
3. Braking switch. Manual provides continuous braking on the ripper wheels. Automatic provides intermittent braking.

4 and 5. Indicator lights for right and left ripper wheel braking.

STEP I

6. This switch sets the angle of the ripper wheel when it is braking in the first step of the scarification sequence. The angles shown in the diagram illustrate the positioning of the ripper in relation to the mean ground level. The angle of Position 1 results in a deep scalp because the ripper is pulled deeper into the ground as the machine moves forward. Position 3 provided the shallowest scalp.
7. The length of braking time in Step I is controlled by this switch. When the control is set higher, a longer braking time gives a longer scalp and therefore more soil material is accumulated.

STEP II

8. In the second step of the scarification sequence, this switch controls the action of the ripper. In position 0, the rippers are freely revolving and act minimally on the mound. In position 1, the rippers are braked at the angle shown. This braking can be used to compress the mound and prevent it from falling back into the scalp when the treatment direction is uphill. As well, when Switch 6 is set at 0, this switch set at 1 can provide continuous shallow disturbance.
9. The length of braking time in Step II is set by this switch.
10. The settings of switch 7 and 9 can be modified using this switch when the prime mover speed is changed. The settings are Slow, Medium, and Fast, according to the rate of travel of the prime mover.

APPENDIX 3. Classification of mound attempts

The classification of mound attempts included the description of the configuration, composition, and dimensions of the attempt result. The conditions considered possible after observation of the machine are listed below. Mound Classes 1 through 4 were judged acceptable planting sites, provided conditions of ground contact were met. Ground contact of 50% was considered critical and this was also determined at the time of assessment. In both blocks, assessment occurred immediately after treatment; the effects of settling during the winter were taken into account in part by the 50% allowance. Mineral-soil capping depth was determined by inserting a shovel into the mound in several places to judge the appropriate class. Height was measured in relation to mean ground level. Length and width measurements of both mound and scalp were to the nearest 10-cm figure.

1	Greater than or equal to 14 cm of mineral soil in cap over inverted organic layer.
2	6-13 cm of mineral soil in cap over inverted organic layer.
3	3-5 cm of mineral soil in cap over inverted organic layer.
4	Greater than or equal to 5 cm of well-decomposed inverted organic layer over undisturbed organic.
5	Less than or equal to 2 cm of mineral soil in cap over inverted organic layer.
6	Less than 5 cm of well-decomposed inverted organic layer over undisturbed organic.
7	Mineral cap over mineral soil.
8	No mound.
9	Inverted organic material.
10	Organic mound, not inverted.
11	Mineral over undisturbed organic.
12	Organic over mineral soil, not inverted.
13	Vertical mound, not inverted.